Indicator: Greenhouse Gas Emissions (348)

The Earth's climate is determined by the balance between energy received from the sun and emitted back to space from the Earth and its atmosphere. Certain gases in the atmosphere, such as carbon dioxide (CO2), methane (CH4) and nitrous oxides (N2O), water vapor and others, trap some of the outgoing energy, retaining heat in the Earth's atmosphere. These are the so-called "greenhouse gases" (GHG).

Some human activities, such as the burning of fossil fuels, emit greenhouse gases and other substances that directly or indirectly affect the balance of incoming and outgoing radiation, thereby affecting climate on regional and global scales. The best understood greenhouse gases emitted by human activities are carbon dioxide, methane, nitrous oxides, and certain fluorinated compounds which all trap heat. Emissions of CO, NOx and nonmethane VOC, and substances that deplete the stratospheric ozone layer also indirectly affect the Earth's radiative balance, for example, by altering greenhouse gas concentrations or changing the reflectivity of clouds.

Changes in GHG emissions are influenced by many long and short-term factors, including population and economic growth, energy price fluctuations, technological changes, and seasonal temperatures. On an annual basis, the overall consumption of fossil fuels, which accounts for most GHG emissions in the United States, generally fluctuates in response to changes in general economic conditions, energy prices, weather, and the availability of non-fossil alternatives (US EPA, 2004).

This indicator represents data and analysis from the US GHG Inventory (US EPA, 2004), an assessment of the anthropogenic sources and sinks of greenhouse gas emissions for the United States and its Territories for the period1990 through 2002, excluding emissions not covered by the UN Framework Convention on Climate Change (e.g. CFC, HFCs, methyl bromide, etc.). The methods for these estimates are documented in US EPA (2004), and accord with guidelines used consistently among other industrialized nations (IPCC 1996). The indicator is expressed in terms of CO2 equivalents (CO2 Eq). Emissions of different gases are weighted by "global warming potentials" (GWP), a measure of how much a given mass of GHG is estimated to contribute to global warming over a selected period of time. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide, of which the GWP is one. This indicator uses GWP recommended by the Intergovernmental Panel on Climate Change (IPCC 1996) for a 100 year time horizon – the amount of a gas's effect on radiative forcing over 100 years.

What the Data Show

Overall, total U.S. emissions have risen by 13 percent (from 6,120 to 6,935 Tg CO2 Eq.) between 1990 and 2002 (Figure 348-1). Emissions are influenced primarily by levels of economic activity and the mix among sectors, weather conditions, fuel choices, and technologies in place, such as the energy efficiency of vehicles or the building stock. The primary greenhouse gas emitted by human activities in the United States is CO2, representing approximately 83 percent of total greenhouse gas emissions. Methane is the second largest GHG emission. Methane emissions have steadily declined over the 1990-2002 period, from 643 to 598 Tg CO2 Eq.

Electricity generation has consistently been the largest producer of GHG emissions, followed by transportation (Figure 348-2). Emissions rates from both sectors have grown steadily during the period from 1990 to 2002, while GHG emissions from industry have decreased over the same period, and those from commercial, agricultural, and residential sectors have remained fairly constant.

Across economic sectors, the largest source of greenhouse gas emissions in the U.S. is combustion of fossil fuels (Figure 348-3). Fossil fuel consumption has accounted for approximately 80 percent of U.S.

greenhouse gas emissions since 1990. Emissions from this source category grew by 17 percent (796.3 Tg CO2 Eq.) from 1990 to 2002 and were responsible for most of the increase in national emissions during this period (US EPA, 2004). Transportation is narrowly the largest emitter of fossil fuel CO2 emissions, slightly exceeding the direct and electricity-related emissions from industry. Residential and commercial sectors, primarily through electricity consumption, account for about 2/3 to ¾ as much emissions as transportation or industry.

Methane, the second most important greenhouse gas emission in the U.S., at 8.6% of the total, comes mostly from waste landfills, leakages from natural gas systems, enteric fermentation (digestion processes) in cattle and other animals, and coal mining (Figure 348-4). Methane also is emitted by a large number of small agricultural and industrial activities. Trends in emissions from the remaining source categories can be found in EPA 2002).

Indicator Limitations

- This indicator does not yet include emissions of greenhouse gases or other radiatively important substances that are not covered by the United National Framework Convention on Climate Change, such as those gases controlled by the Montreal Protocol and its Amendments, including CFCs and HFCs.
- This indicator also does not include aerosols and other emissions that are not well-mixed in the atmosphere, such as sulfate, ammonia, black carbon and organic carbon.

Data Sources

US EPA, Inventory Of U.S. Greenhouse Gas Emissions And Sinks: 1990 – 2002, 2004. Available at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2004.html

References

IPCC (1996) *Climate Change 1995: The Science of Climate Change*. Intergovernmental Panel on Climate Change; J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell, eds.; Cambridge University Press. Cambridge, U.K.

Graphics

Figure 348-1

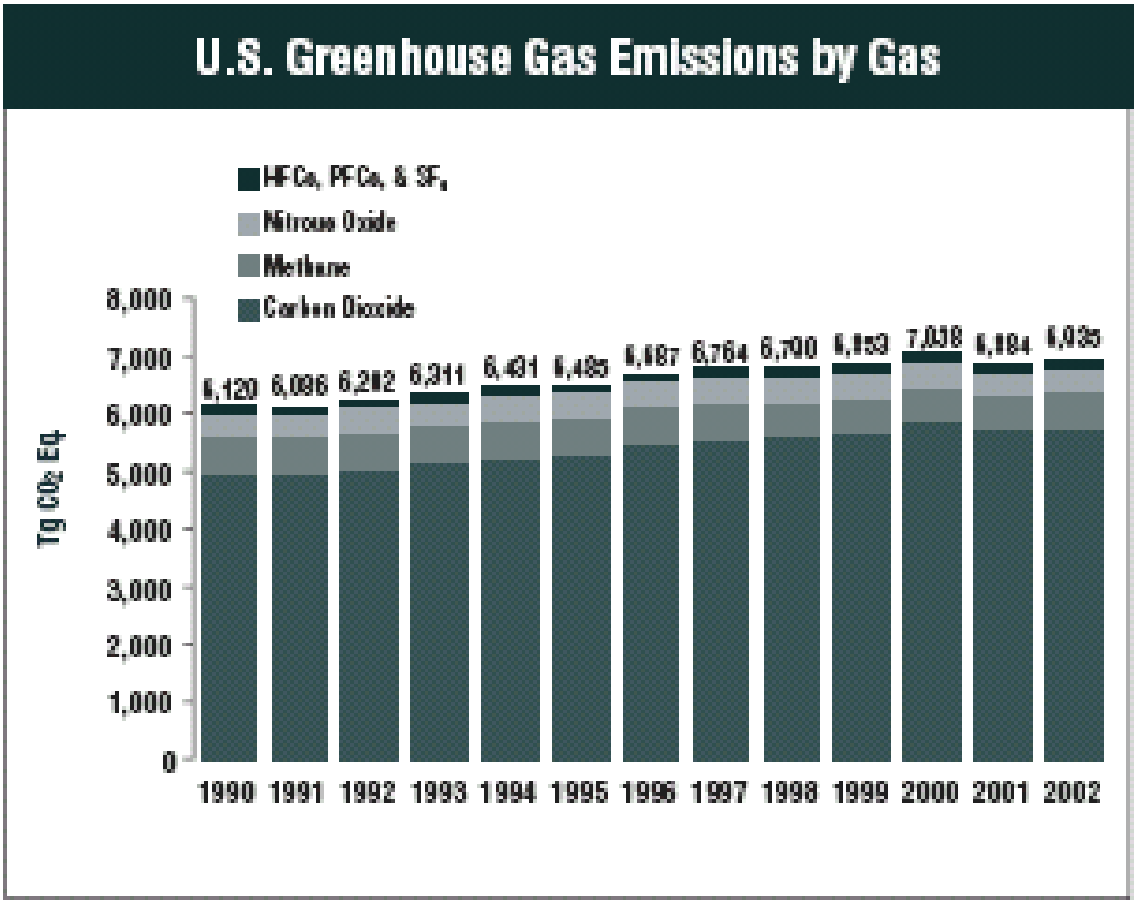


Figure 348-2

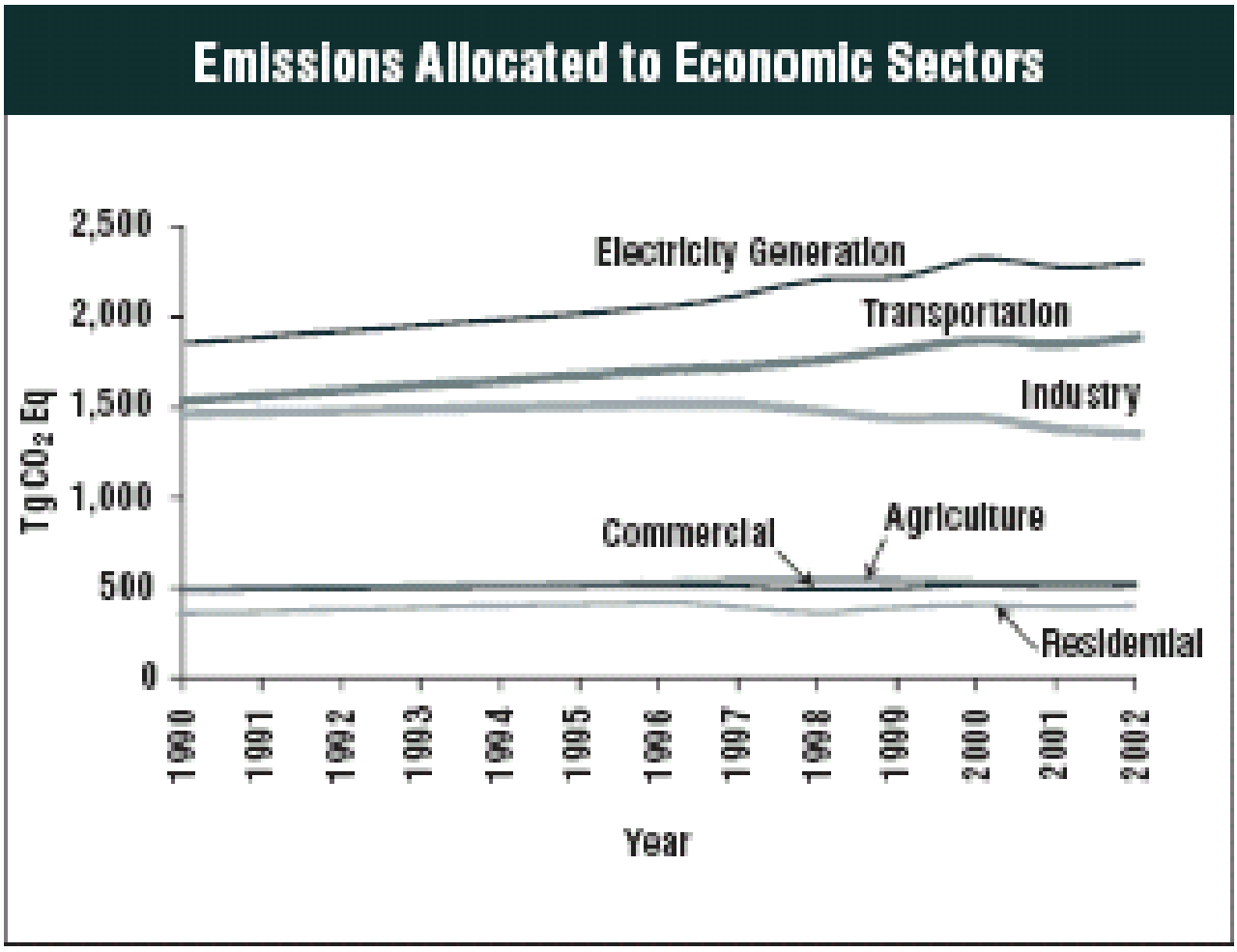

Emissions Allocated to Economic Sectors
2,500
2,000
1,500
1,000
500
0
Tg CO2 Eq
Electricity Generation
Transportation
Industry
Commercial
Agriculture
Residential
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Year

Figure 348-3

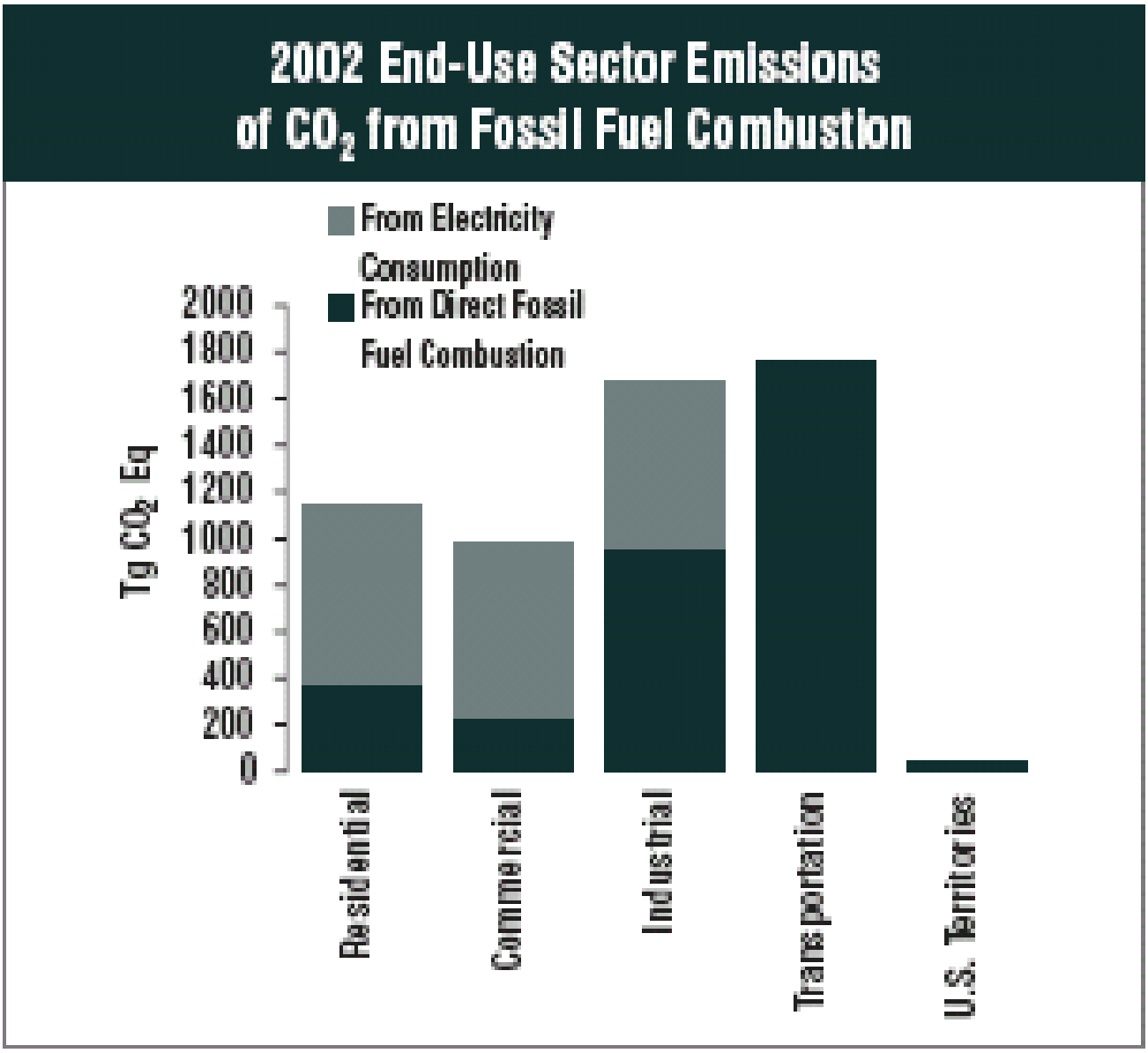
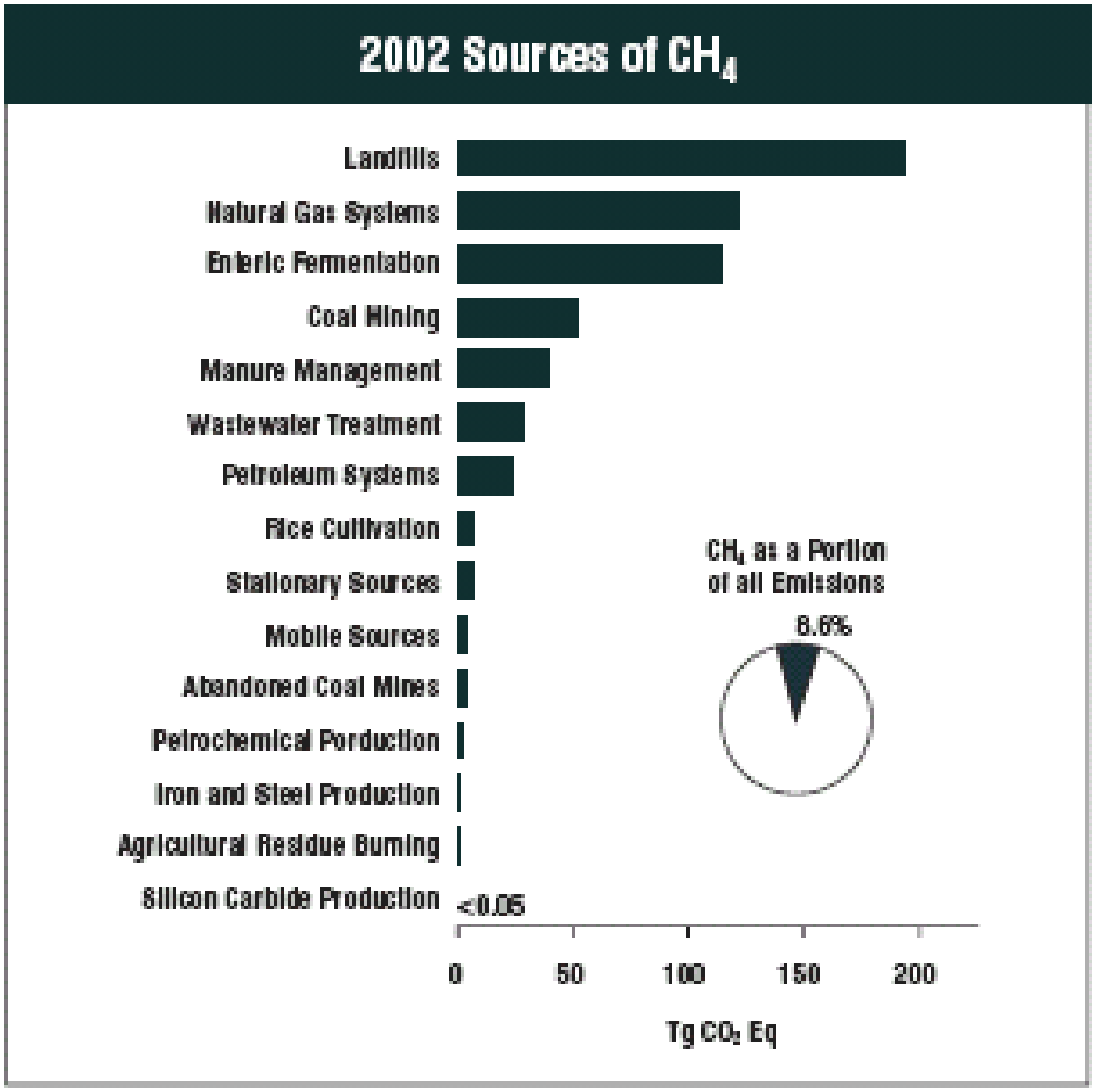

2002 End-Use Sector Emissions of CO_2 from Fossil Fuel Combustion
From Electricity Consumption
From Direct Fossil Fuel Combustion
Tg CO_2 Eq
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Residential
Commercial
Industrial
Transportation
U.S. Territories

Figure 348-4


2002 Sources of CH_4
Landfills
Natural Gas Systems
Enteric Fermentation
Coal Mining
Manure Management
Wastewater Treatment
Petroleum Systems
Rice Cultivation
Stationary Sources
Mobile Sources
Abandoned Coal Mines
Petrochemical Porduction
Iron and Steel Production
Agricultural Residue Burning
Silicon Carbide Production
<0.05
0
50
100
150
200
Tg CO_2 Eq
CH_4 as a Portion of all Emissions
8.6%

R.O.E. Indicator QA/QC

Data Set Name: U.S. GREENHOUSE GAS EMISSIONS
Indicator Number: 348 (114469)
Data Set Source: US Greenhouse Gas Inventory, 1990 to 2002
Data Collection Date: 1990 to present
Data Collection Frequency: mostly 1 year; some source variation
Data Set Description: U.S. Greenhouse Gas Emissions by Sector and Gas
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The emission and source activity data from which the emission estimates are derived are described thoroughly in the report US Greenhouse Gas Emissions, 1990 - 2002, which can be found at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2004.html The scientifically approved methods and discussion of estimation of uncertainty can be found in the IPCC GHG Inventory Guidelines, at http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm (Revised 1996 IPCC Guidelines) and http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (Good Practice Guidance and Uncertainty Management).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The US GHG Inventory is based on scientifically developed and reviewed methods, documented in the IPCC GHG Inventory Guidelines, at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm (Revised 1996 IPCC Guidelines). The US GHG Inventory, along with its accompanying Common Reporting Format tables, serves as a thorough assessment of the anthropogenic sources and sinks of greenhouse gas emissions for the United States for the time series 1990 through 2002. The Inventory covers only the years identified in the inventory; it is not extrapolated or interpolated, except in the case of interpolation between years in which the US forest inventories are conducted for that sector. Although the Inventory is intended to be comprehensive, certain sources have been identified yet excluded from the estimates presented due to data limitations or a lack of thorough understanding of the emission process. For a complete list of sources excluded, see Annex 5 of the final report. Fuller discussion of the sampling and data sources on which the Inventory is based can be found at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2004.html

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. See http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm (Revised 1996 IPCC Guidelines) and http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (Good Practice Guidance and Uncertainty Management). In some cases, the US estimation methods or data quality are better than what has

been approved in the IPCC Guidelines and Good Practice Guidance. The detailed descriptions of these, source by source, are in the US GHG Inventory (see T1Q2 for weblink).

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The US GHG Inventory tries to be comprehensive of all source or removal types, excluding, however, those emissions that are not covered by the UN Framework Convention on Climate Change (e.g. CFC, HFCs, methyl bromide, etc.) Information on these can be found in the ROE section on Stratospheric Ozone Depletion. Those estimates, however, are not entirely consistent with those in the US GHG Inventory. Further, although continuous monitoring of CO2 and some other emissions are available for large energy combustion facilities in the US, more comprehensive monitoring of source types, sizes and types of facilities would be desirable to reduce the uncertainty estimates in the Inventory QA/QC. Discussion of this, source by source, is available in the US GHG Inventory publication (see T1Q2 for weblink).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not applicable.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No. This indicator shows the net time series of emissions. No threshold level for "dangerous" has been established for emissions or concentrations in the atmosphere, although the general objective to establish this level is an obligation of the U.S. and other Parties to the United Nations Framework Convention on Climate Change (1992).

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation is available is available in the US GHG Inventory publication (see T1Q2 for weblink).

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. See the US GHG Inventory publication (see T1Q2 for weblink). The EPA contact person is Leif Hockstad, hockstad.leif@epa.gov, (202)343-9432.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The description of methods, data and estimates is extremely complete and has been through thorough peer and public review. Details regarding the methods, QA/QC and peer reviews are described in the US EPA 2004 Inventory, and further information can be obtained from the EPA Contact Person.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The United States recently implemented a systematic approach to QA/QC. While QA/QC has always been an integral part of the U.S. national system for Inventory development, the procedures followed for the current inventory have been formalized in accordance with the QA/QC plan and the UNFCCC reporting guidelines. While the current U.S. emissions inventory provides a solid foundation for the development of a more detailed and comprehensive national inventory, there are uncertainties associated with the emission estimates. Some of the current estimates, such as those for CO2 emissions from energy related activities and cement processing, are considered to have low uncertainties. For some other categories of emissions, however, a lack of data or an incomplete understanding of how emissions are generated increases the uncertainty associated with the estimates presented. Recognizing the benefit of conducting an uncertainty analysis, the UNFCCC reporting guidelines follow the recommendations of the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (hereafter referred to as the IPCC Good Practice Guidance) and require that countries provide single point estimates for many source and sink categories. Currently, a qualitative discussion of uncertainty is presented for all source and sink categories in the US Greenhouse Gas Inventory. Within the discussion of each emission source, specific factors affecting the uncertainty surrounding the estimates are discussed. Most sources also contain a quantitative uncertainty assessment, in accordance with the new UNFCCC reporting guidelines. Thorough discussion of these points can be found in the US GHG Inventory publication (see T1Q2 for weblink).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The US GHG Inventory, along with its accompanying Common Reporting Format tables, serves as a thorough assessment of the anthropogenic sources and sinks of greenhouse gas emissions for the United States for the time series 1990 through 2002. Although this inventory is intended to be comprehensive, certain sources have been identified yet excluded from the estimates presented for various reasons. Generally speaking, sources not accounted for in this Inventory are excluded due to data limitations or a lack of thorough understanding of the emission process. The United States is continually working to improve upon the understanding of such sources and seeking to find the data required to estimate related emissions. As such improvements are made, new emission sources are quantified and included in the Inventory. For a complete list of sources excluded, see Annex 5.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. See the US GHG Inventory publication (see T1Q2 for weblink) and http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (Good Practice Guidance and Uncertainty Management).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. Even considering the uncertainties of omitted sources and lack of precision in known and estimated sources, the conclusions inferred from the data are solid. The quality of the indicator is very high.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

No. Although there are gaps in the data and limitations in the measurements upon which the estimates are based, the estimates provide a good representation of the trends in the indicator over the time period for which these estimates are made.